JP 3448636

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2001-074673

(43)Date of publication of application : 23.03.2001

(51)Int.Cl. G01N 23/22

(21)Application number : 11-248524

(22)Date of filing : 02.09.1999

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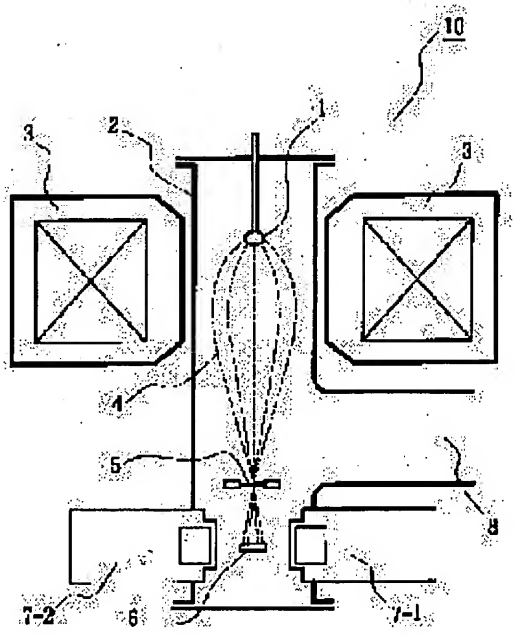
(54) APPARATUS AND METHOD FOR EVALUATION OF MATERIAL BY USING POSITIVE ELECTRONS

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain an apparatus and a method, for the evaluation of a material by using positive electrons, in which the S/N ratio and the time resolution of the evaluation are high even when a positive-electron-beam source is separated from the material to be measured and in which the crystallinity of the material to be measured can be evaluated precisely in a comparatively short time.

SOLUTION: In this material evaluation apparatus 10, a positive-electron-beam source 1, an electromagnetic lens 3, a positive electron detector 5, a first γ-ray detector 7-1 and a second γ-ray detector 7-2 are provided. Then, positive electrons which are emitted from the positive-electron-beam source 1 are focused in the direction of a material 6, to be measured, by a magnetic field which is generated by the electromagnetic lens 3. In addition, the inside of a vacuum container 2 is vacuum-evacuated through an evacuation port 8. Therefore, a positive-electron flying route up to the material 6, to be measured, from the positive-electron-beam source 1 is maintained to be vacuum. The life of the positive electrons is measured on the basis of the time which elapses until γ-rays emitted from the material 6 to be measured are detected by the γ-ray detectors 7-1, 7-2 since the positive electronc are passed through the positive electron detector 5.



LEGAL STATUS

[Date of request for examination] 02.09.1999

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number] 3448636

[Date of registration] 11.07.2003

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

PRIOR ART

[Description of the Prior Art] The demand to the ingredient used in various fields is still severer with altitude in recent years and progress of a precise technique. Especially, there are very few impurities and, moreover, the ingredient with which the defect inherent was also reduced by the degree of pole is demanded strongly. For example, for operational stability of a circuit, it is a super-high grade more than ten nine %, and moreover, there is no rearrangement and the silicon used for substrates, such as super-large scale integration (VLSI), requires the single crystal also with possible few few defects like a hole or the hole aggregate, i.e., a crystallographic very small defect. There is an approach which has ****ed measurement assessment enough and carries out the gamma ray generated in case a positive electron life is measured or positive electron disappears as an approach of detecting very sensitively such an atomic hole that exists in an ingredient, the hole aggregate, a class, an amount of a defect of a crystal lattice like a rearrangement, etc.
[0003] With positive electron, it is one of the antiparticles of the electron which has the same mass as an electron and had the charge of plus of the completely same absolute value as an electron. If incidence of this positive electron is carried out into ingredients, such as a metal, incident kinetic energy will be lost for a short time, and subsequent behavior will turn into thermal motion. Ingredients, such as a metal, a semi-conductor, and a compound, are made from the aggregate of the atom which is the structure which the electron with the charge of minus enclosed in the surroundings of the nucleus which has the charge of plus, and many of these ingredients have taken the gestalt of the crystalline to which the atom which constitutes the aggregate carried out the regular three-dimensional array to three-dimension space. For example, as a metaled crystal, since it is made of the array of ion with the charge of plus, with ion, the positive electron which entered into it is repelled by the same sign comrade, it collides with an electron, coalesces and disappears in the location between grids mainly distant from ion.
[0004] However, since the crystal lattice defect for which atoms, such as a hole and a rearrangement, were insufficient is relatively charged in minus, the positive electron of plus is first captured by the part, collides with ****** soon and carries out coalesce dissipation. When this positive electron collides with an electron and carries out coalesce dissipation, energy emits the two gamma rays with the almost opposite direction by 511keV(s). It collides with an electron, and time amount after positive electron carries out incidence to an ingredient until it disappears differs by the case where it is caught by the case where it exists in the part without a defect, and the defect, and changes also with forms of a defect.
[0005] Then, the condition of a defect can be grasped if the time amount change to dissipation is analyzed from the incidence of positive electron. Moreover, the gamma ray generated from dissipation with the electron which is moving about produces a gap of the wavelength by the Doppler effect, and produces a gap with the energy in which the electron has also whenever [angular relation / of the gamma ray emitted in the opposite direction]. Therefore, the information on a defect can be known in detail to **** by analyzing these.
[0006] The positive electron assessment approach for measuring the class and amount of a crystal lattice defect in the above ingredients is performed using the property of the positive electron mentioned above. Positive electron is generated in the breaking process of beta+ disintegration mold radioisotope. Then, generally in the ingredient assessment approach using the above positive electron, sticking a line source and a measured ingredient and measuring the lattice defect of said measured ingredient, using this radioisotope as a line source, is performed. For example, 22Na has a long half-life, is easy to come to hand, by handling being easy and having forms, such as NaCl, since it is stable also to ******, is usually enclosed with capsules, such as nickel foil, and is used as a positive electron line source.
[0007] Since this 22Na emits the gamma ray of 1.28MeV in the case of beta+ breaking, a line source is made into the

form inserted with a measured ingredient, and is stuck, detectors, such as a scintillation counter, are prepared, and time amount until the gamma ray of 511kev is detected is measured after sensing the gamma ray of 1.28Mev. That is, since the distance of a line source and a measured ingredient is very near, it is at the start event in which the time of the gamma ray of 1.28MeV being emitted carried out incidence to the ingredient of positive electron, and the time of the gamma ray of 511keV being detected can consider as the event of positive electron disappearing. Thus, the information on more defects can be extremely acquired to high sensitivity by measuring the life of positive electron, detecting change of the bleedoff energy distribution called Doppler broadening, or analyzing the bleedoff include angle of the gamma ray of 511keV(s) etc. to a pan.
[0008]

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to the ingredient assessment equipment and the assessment approach of having used positive electron, and relates to the ingredient assessment equipment and the ingredient assessment approach for mainly detecting and evaluating crystal defect information, such as a hole, the hole aggregate, and a rearrangement, in ingredients, such as a metal, a semi-conductor, and a compound, in more detail.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, it was difficult to heat or cool a sample and change the condition for there to be a limitation by the approach of sticking a device under test to a line source as mentioned above in the case of the sample of a variant configuration etc., and to measure the lattice defect of a measured ingredient freely.
[0009] On the other hand, one person of this invention persons has isolated and arranged the positive electron line source and the measured ingredient, placed thin plastic scintillator between said positive electron line source and said measured ingredient, detected the time of day when positive electron passes through that, and proposed the approach of getting to know the incidence time of day of the positive electron to an ingredient. Let time amount after positive electron carries out incidence in the case of a metal etc. until it disappears be 100 - 300ps (picosecond: 10-12) extent. Therefore, in measurement of such a short time, the time amount taken for the positive electron generated in the positive electron line source to fly, and to carry out incidence of the space to a measured ingredient will also enlarge a measurement error. Therefore, in the above-mentioned approach, when passing the positive electron detector in which the time of initiation of measurement was prepared in the near location not with a positive electron's in positive electron line source generating event but with the measured ingredient, it has set up.
[0010] However, if a positive electron line source and a measured ingredient are detached and arranged as mentioned above, as long as white positive electron will be used, the problem of the S/N ratio and time resolution of measurement and ingredient assessment falling occurs. Then, pass between the sector mold magnetic poles put on the same parallel as what uses for mass analysis the positive electron emitted from the positive electron line source, or an electromagnetic lens is passed. only positive electron with the energy of the specific range is classified, and after making it converge, attempts, such as carrying out incidence to said measured ingredient, are also made (: besides Taiji Shirai -- the Japan Institute of Metals -- volume [59th] No. 6 (1995)) P.679 and Taiji Shirai: Production, a technique, volume [48th] No. 4 (1996), P.50.
[0011] However, when it isolated greatly and the positive electron line source and the measured ingredient had been arranged also by such improvement, the situation that the number of the positive electron which carries out incidence to a measured ingredient became very small to the number of positive electron generated in the positive electron line source was in the unavoidable situation. For this reason, the problem that a S/N ratio and time resolution will also fall had both arisen. [in / as if the measurement time amount of a measured ingredient increases substantially / measurement and ingredient assessment] Moreover, although using the positive electron line source of a lot of radioisotope is also considered in order to make the number of incidence positive electron to a measured ingredient increase, difficult ** of the implementation is carried out from a viewpoint of safety.
[0012] This invention by carrying out incidence of the positive electron to a measured ingredient, and measuring the gamma ray emitted by the life of said positive electron, and dissipation of said positive electron from a measured ingredient In the ingredient assessment equipment and the ingredient assessment approach of evaluating the crystallinity of said measured ingredient When a positive electron line source and a measured ingredient are made to isolate, it has a high S/N ratio and time resolution, and it aims at offering the ingredient assessment equipment which can perform crystalline assessment of said measured ingredient to accuracy comparatively for a short time, and the ingredient assessment approach.

[Translation done.]

MEANS

[Means for Solving the Problem] The ingredient assessment equipment of this invention is equipped with a positive electron line source, an electromagnetic lens, a positive electron detector, and a gamma ray detector that the above-mentioned object should be attained. And while said positive electron line source is installed in the magnetic field of said electromagnetic lens, said positive electron detector is installed between said positive electron line source and said measured ingredient. Furthermore, said positive electron line source is characterized by maintaining the positive electron trajectory from said positive electron line source to said measured ingredient at a vacuum while isolating from said measured ingredient and installing it.

[0014] Moreover, the ingredient assessment approach of this invention installs said positive electron line source into an electromagnetic lens, and it holds the positive electron trajectory from said positive electron line source to said measured ingredient to a vacuum while converging efficiently the positive electron generated in said positive electron line source on measured material orientation. And by installing a positive electron detector between said positive electron line source and said measured ingredient The time of day when the positive electron emitted towards said measured ingredient from said positive electron line source passes said positive electron detector is detected. It considers as the criteria time of day for assessment initiation of this time of day of the crystallinity of said measured ingredient, and is characterized by making said positive electron line source isolate from said measured ingredient, and evaluating the crystallinity of said measured ingredient.

[0015] this invention persons tried examination wholeheartedly that the above-mentioned object should be attained. Generally in the ingredient assessment approach using the above positive electron, radioisotope is used as a positive electron line source. Since positive electron is uniformly emitted in all the directions from radioisotope, when a positive electron line source and a measured ingredient are isolated, the number of positive electron which contributes to assessment of an ingredient will decrease extremely. For this reason, as compared with the case where a positive electron line source and a measured ingredient are stuck, measurement time amount will become extremely long. Then, this invention persons examined how to carry out as many incidence of the positive electron generated in the positive electron line source as possible to a measured ingredient.

[0016] The method of being in the middle of flight of positive electron, passing a magnetic field, and classifying the thing of specific energy has already been performed as mentioned above, and completing an electron ray with an electromagnetic lens is performed to usual in another side and an electron microscope. this invention persons examined increasing the number of the positive electron which goes to the direction of a measured ingredient from this viewpoint using this electromagnetic lens. It is discharged from an electron gun, and after making accelerated electron flow the extent parallel which are slits etc., it is made to converge with an electromagnetic lens in the case of an electron microscope. On the other hand, since positive electron is emitted in all the directions almost uniformly from a positive electron line source, it can carry out and carry out the thing only of the positive electron which has flown to the direction of an electromagnetic lens to the object of convergence from a positive electron line source.

[0017] Then, since the number of the positive electron which enters in an electromagnetic lens was increased, the positive electron line source was put in into the magnetic field of an electromagnetic lens, and the reinforcement of an electromagnetic lens was adjusted. Consequently, although based also on the energy of the generated positive electron, it turned out that the positive electron emitted to the range of 0-**50 degrees from a positive electron line source to the direction of a measured ingredient may be completed as the device under test which is separated from a positive electron line source enough.

[0018] Moreover, before the positive electron emitted from the positive electron line source reached the measured ingredient, when positive electron collided with a gas molecule, and was scattered about or annihilated, it tried so that the number of positive electron which reaches a measured ingredient as a result might not decrease. Consequently, by setting the positive electron trajectory from a positive electron line source to a measured ingredient as a degree of vacuum higher than 10-4torr extent, measurement sensibility improved and it became clear that a high S/N ratio was obtained in ingredient assessment.
[0019] Furthermore, it is not from the event of generating in a positive electron line source, and it is necessary to measure time amount until it considers the event of carrying out incidence to a measured ingredient as a start and disappears for exact measurement of a positive electron life. A measurement error will become large, if detection of the gamma ray emitted when it generates in a positive electron line source is the start of the incidence to the ingredient of positive electron when a positive electron line source and a measured ingredient are detached and placed. Therefore, the positive electron passed in the location close to a measured ingredient was detected, and the positive electron detector was installed between the positive electron line source and the measured ingredient that this passed time of day should be considered as the start event of a positive electron life. This invention is made as a result of the above-mentioned examination by this invention persons.
[0020] When a positive electron line source and a measured ingredient are isolated, while having a high S/N ratio and time resolution according to this invention, in a short time, an exact ingredient can be evaluated comparatively. For this reason, a cooling system, heating apparatus, etc. to a measured ingredient can be installed, and crystallinity in case an ingredient is in the condition of arbitration can be measured and evaluated with a sufficient precision. In addition, the crystallinity as used in the field of this invention means properties, such as a lattice defect of a measured ingredient which was mentioned above.
[0021]
[Embodiment of the Invention] Hereafter, this invention is explained to a detail based on the gestalt of implementation of invention. Drawing 1 is the mimetic diagram showing an example of the ingredient assessment equipment of this invention. The ingredient assessment equipment 10 shown in drawing 1 is equipped with the positive electron line source 1, an electromagnetic lens 3, the positive electron detector 5, and the 1st gamma ray detector 7-1 and 2nd gamma ray detector 7-2. And the positive electron line source 1 is installed between electromagnetic lenses 3 so that it may be located in the magnetic field which an electromagnetic lens 3 generates. Moreover, the measured ingredient 6 is installed by the positive electron line source 1 and the positive electron detector 5, and the list into a vacuum housing 2, and the positive electron flight distance from the positive electron line source 1 to the measured ingredient 6 is held at a vacuum by carrying out evacuation from the exhaust port 8 established in the vacuum housing 2.
[0022] Furthermore, the measured ingredient 6 is arranged in this order in the positive electron line source 1 and the positive electron detector 5, and the list at the same line top. And in right and left of the measured ingredient 6, as the 1st gamma ray detector 7-1 and 2nd gamma ray detector 7-2 sandwich the measured ingredient 6, they are arranged, respectively.
[0023] By the magnetic field which an electromagnetic lens 3 generates, the positive electron emitted from the positive electron line source 1 converges in the direction of the measured ingredient 6, and forms the positive electron line 4. And the positive electron line 4 progresses toward the measured ingredient 6, and passes the positive electron detector 5 installed on the way. The positive electron line 4 measures the time of day which passed the positive electron detector 5, and makes this the measurement criteria time of day of a positive electron life.
[0024] And incidence of the positive electron line 4 which passed the positive electron detector 5 is carried out into the measured ingredient 6, and it evaluates the crystallinity of an ingredient. Positive electron is captured by the defect in an ingredient, and it generates, in case it collides with an electron and disappears there, and the gamma ray emitted outside from the measured ingredient 6 is detected by the 1st and 2nd gamma ray detectors 7-1 and 7-2. Therefore, the life of positive electron is measurable by measuring time amount until it detects a gamma ray from the time of day at the time of passing the positive electron detector 5. And the crystalline class and crystalline configuration of a defect in the measured ingredient 6 can be known from the various positive electron lives which carried out in this way and were measured.
[0025] Drawing 2 is drawing in which it was expanded and shown near the electromagnetic lens 3 in drawing 1 . A positive electron line source will not be limited especially about the location, if it is installed so that it may be located all over the magnetic field which an electromagnetic lens generates. However, it is desirable to install a positive

electron line source in the upper half in the magnetic field which an electromagnetic lens generates. For example, as shown at drawing 2 in the case of ingredient assessment equipment 10 as shown in drawing 1 , it is desirable to be located in the upper half section 14 of the magnetic field field 11 generated with an electromagnetic lens 3. By this, the rate which converges to the measured material orientation of the positive electron generated from the positive electron line source can be increased further, and the object of this invention can be attained more effectively.

[0026] Furthermore, since the positive electron line source 1 shown in drawing 1 is the same as that of the above, it is desirable to arrange on the medial axis 12 of an electromagnetic lens 3. Moreover, it will be limited, especially if a positive electron line source is installed in the magnetic field which an electromagnetic lens generates and the object of this invention can be attained also about the strength of the magnetic field generated by the electromagnetic lens, and it is not a **** thing.

[0027] However, in the core 13 in the magnetic field of an electromagnetic lens, for example, the core in the magnetic field shown in drawing 2 in ingredient assessment equipment 10 as shown in drawing 1 , it is desirable that the strength of a magnetic field is 1000-8000 gauss, and it is desirable that it is further 3000-5000 gauss. The number of positive electron which the focusing degree of the positive electron emitted from the positive electron line source contributes to measurement of increase and a measured ingredient by this increases. Therefore, the S/N ratio and time resolution of measurement and assessment increase in a measurement time amount list, and the object of this invention can be attained more effectively.

[0028] Moreover, if the between from the positive electron line source 1 to the measured ingredient 6 is held at a vacuum at the case of the positive electron trajectory 10 from a positive electron line source to a measured ingredient, for example, the ingredient assessment equipment shown in drawing 1 , and the object of this invention can be attained, it will not be limited especially about a degree of vacuum in the meantime. However, as for said positive electron trajectory, it is desirable to be held at the pressure of 1x10 to 4 or less torrs, and it is desirable to be held at the pressure of further 1x10-6 - 1x10-9torr. The rate that the positive electron emitted from the positive electron line source is scattered about by this can decrease, and the rate of the positive electron contributed to measurement and assessment of a measured ingredient can be raised.

[0029] Plastics SHINCHIRE 1 TA can be used as a positive electron detector. However, in order to lessen loss of positive electron, when thickness of plastic scintillator is made small, there is a problem that detection sensitivity will fall. Therefore, it is desirable to replace with plastic scintillator and to use the Avalanche photodiode. The signal detected by this Avalanche photodiode is amplified by the photo multiplier, and serves as criteria time of day at the time of measuring a positive electron life which was mentioned above.

[0030] Moreover, such a positive electron detector is arranged near the location where the positive electron line 4 converges, so that positive electron can pass most efficiently (transparency), for example, as shown in drawing 1 . Moreover, when the magnitude of a vacuum housing 2 is comparatively small, it can also arrange directly under the positive electron line source 1. And when it constitutes a positive electron detector from an Avalanche photodiode as mentioned above, as for the object holding the transmission coefficient (permeability) and detector efficiency of positive electron to the thickness, it is desirable that it is 50-200 micrometers.

[0031] Furthermore, in the ingredient assessment equipment 10 shown in drawing 1 , the gamma ray detector consists of the 1st gamma ray detector 7-1 and 2nd gamma ray detector 7-2. And in right and left of the measured ingredient 6, as this is inserted, opposite arrangement is carried out. The gamma ray emitted to the opposite sense from a measured ingredient by this can be measured with a sufficient precision, and a crystalline assessment precision of a measured ingredient can be raised. However, even if it does not use such two gamma ray detectors, the object of this invention can fully be attained.

[0032] Although it is not especially limited as a positive electron line source if positive electron is emitted, 22Na (positive-electron average energy: 350keV), 68germanium (positive-electron average energy: 800keV), etc. with which the number of bleedoff positive electron was enclosed with metal capsules, such as many Ti with a long half-life, can be used. As an electromagnetic lens, a cylinder-like coil can be installed in a lens which is used for an electron microscope etc., and what was excited through the current to this coil can be used. The usual scintillation counter etc. can be used as a gamma ray detector.

[0033] Drawing 3 is the mimetic diagram showing the modification of the ingredient assessment equipment shown in drawing 1 . In addition, about the same part as the ingredient assessment equipment shown in drawing 1 , it expresses using the same sign. The ingredient assessment equipment 20 shown in drawing 3 is installing the additional

electromagnetic lens 15 between the positive electron detectors 5 of ingredient assessment equipment 10 and the measured ingredients 6 which are shown in drawing 1 . Thereby, since the positive electron line 4 converges again and comes to carry out incidence to the measured ingredient 6 after it passes the positive electron detector 5, it can raise the S/N ratio and time resolution of measurement and ingredient assessment. Moreover, it cannot call at the location of a positive electron detector, but various fixtures and measuring instruments can be installed.

[0034] Also in ingredient assessment equipment 20 as shown in drawing 3 , it is the same as the ingredient assessment equipment 10 shown in drawing 1 about the location in which the positive electron line source 1 etc. is installed.

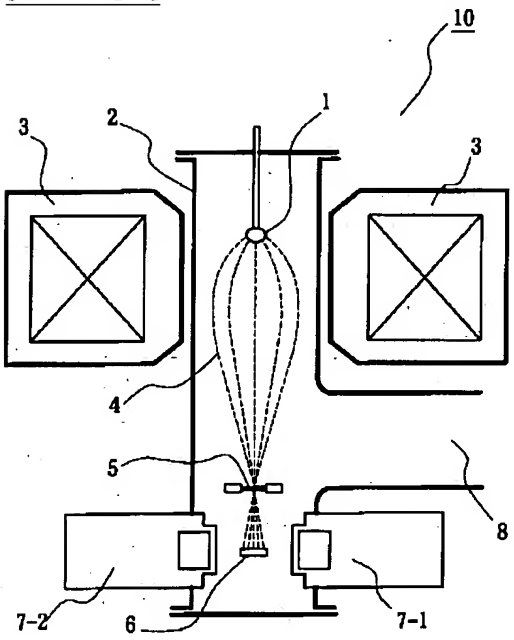
[Translation done.]

* NOTICES *

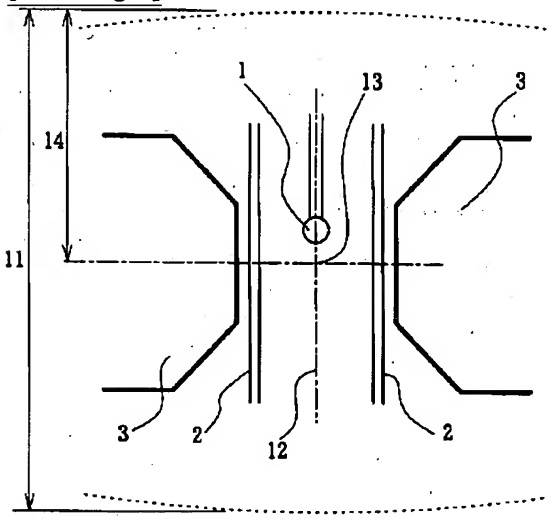
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

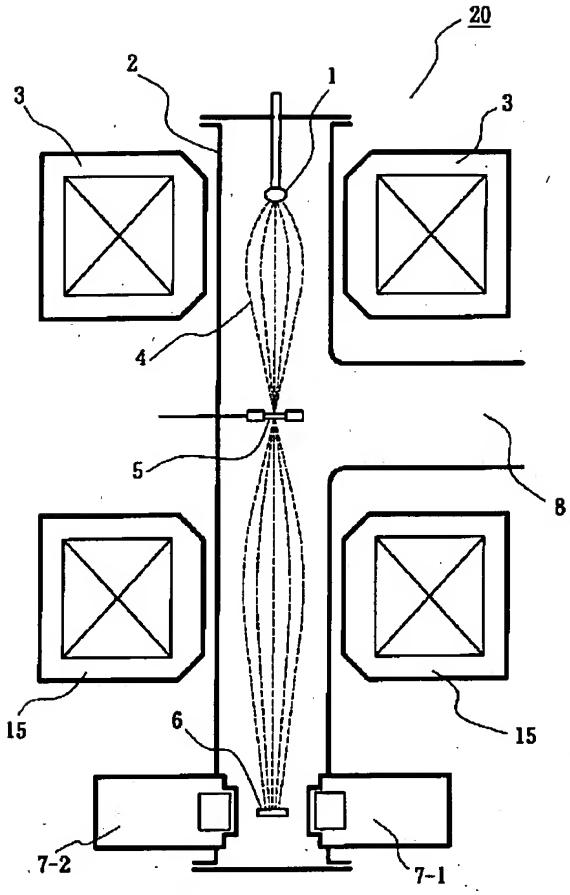
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] It is ingredient assessment equipment by which the crystallinity of said measured ingredient is evaluated by carrying out incidence of the positive electron to a measured ingredient, and measuring the life of said positive electron. Said ingredient assessment equipment It has a positive electron line source, an electromagnetic lens, a positive electron detector, and a gamma ray detector. While isolating from said measured ingredient, installing said positive electron line source while it is installed in the magnetic field of said electromagnetic lens, and installing said positive electron detector between said positive electron line source and said measured ingredient Ingredient assessment equipment characterized by holding the positive electron trajectory from said positive electron line source to said measured ingredient at the vacuum.
[Claim 2] said positive electron line source -- said electromagnetism -- the ingredient assessment equipment according to claim 1 characterized by being installed in the upper half in the magnetic field of a range.
[Claim 3] Ingredient assessment equipment according to claim 1 or 2 with which the strength of the magnetic field in the core in the magnetic field of said electromagnetic lens is characterized by being 1000-8000 gauss.
[Claim 4] Said positive electron trajectory is ingredient assessment equipment according to claim 1 to 3 characterized by being held at the pressure of 1x10 to 4 or less torrs.
[Claim 5] Said positive electron detector is ingredient assessment equipment according to claim 1 to 4 characterized by being the Avalanche photo diode.
[Claim 6] It is ingredient assessment equipment of the any 1 publication of claims 1-5 which said gamma ray detector consists of the 1st gamma ray detector and 2nd gamma ray detector, and is characterized by said the 1st gamma ray detector and said 2nd gamma ray detector having countered on both sides of said measured ingredient.
[Claim 7] Ingredient assessment equipment according to claim 1 to 6 characterized by preparing an additional electromagnetic lens between said positive electron detector and said measured ingredient.
[Claim 8] Ingredient assessment equipment according to claim 1 to 7 characterized by having at least one side of the cooling system for cooling the heating apparatus and said measured ingredient for heating said measured ingredient in a vacuum in a vacuum.
[Claim 9] By carrying out incidence of the positive electron generated in the positive electron line source to a measured ingredient, and measuring the life of said positive electron While converging the positive electron which is the ingredient assessment approach of evaluating the crystallinity of said measured ingredient, installed said positive electron line source in the magnetic field of an electromagnetic lens, and was generated in said positive electron line source on measured material orientation By holding the positive electron trajectory from said positive electron line source to said measured ingredient to a vacuum, and installing a positive electron detector between said positive electron line source and said measured ingredient The time of day when the positive electron emitted towards said measured ingredient from said positive electron line source passes said positive electron detector is detected. The ingredient assessment approach which makes this time of day the crystalline valuation-basis time of day of said measured ingredient, and is characterized by making said positive electron line source isolate from said measured ingredient, and evaluating the crystallinity of said measured ingredient.
[Claim 10] said positive electron line source -- said electromagnetism -- the ingredient assessment approach according to claim 9 characterized by installing in the upper half in the magnetic field of a range.
[Claim 11] The ingredient assessment approach according to claim 9 or 10 that the strength of the magnetic field in the

core in the magnetic field of said electromagnetic lens is characterized by being 1000-8000 gauss.
[Claim 12] Said positive electron trajectory is the ingredient assessment approach according to claim 9 to 11 characterized by being held at the pressure of 1x10 to 4 or less torrs.
[Claim 13] The ingredient assessment approach according to claim 9 to 12 which sandwiches said measured ingredient with the 1st gamma ray detector and 2nd gamma ray detector, and is characterized by measuring simultaneously the dissipation gamma ray mutually emitted to an opposite direction from said measured ingredient.

[Translation done.]